

CLAIMS

What is claimed is:

- 1 1. A magnetic head, comprising:
  - 2 an antiparallel (AP) pinned layer structure having at least two pinned layers
  - 3 having magnetic moments that are self-pinned antiparallel to each other;
  - 4 and
  - 5 a free layer structure spaced apart from the AP pinned layer structure, the free
  - 6 layer structure comprising:
    - 7 a first free layer having a magnetic moment;
    - 8 a second free layer having a magnetic moment pinned antiparallel to the
    - 9 magnetic moment of the first free layer; and
    - 10 a third free layer having a magnetic moment pinned antiparallel to the
    - 11 magnetic moment of the second free layer.
- 1 2. A head as recited in claim 1, wherein a net magnetic moment of the second and
- 2 third free layers is negligible.
- 1 3. A head as recited in claim 1, wherein a thickness of each of the free layers
- 2 perpendicular to planes of the free layers is less than about 100 Å.

- 1 4. A head as recited in claim 1, wherein a thickness of the first free layer is greater
- 2 than thicknesses of the second and third free layers, individually, the thicknesses
- 3 being measured in a direction perpendicular to a plane of the first free layer.
  
- 1 5. A head as recited in claim 1, further comprising hard bias layers positioned
- 2 towards opposite track edges of the free layer structure.
  
- 1 6. A head as recited in claim 1, wherein the second free layer is constructed of a
- 2 material having a lower electrical conductivity than the first and third free layers.
  
- 1 7. A head as recited in claim 6, wherein second free layer includes at least NiFe,
- 2 wherein the first and third free layers include at least CoFe.
  
- 1 8. A head as recited in claim 1, further comprising a Cu spacer layer positioned
- 2 between the AP pinned layer structure and the free layer structure.
  
- 1 9. A head as recited in claim 1, wherein the head forms part of a GMR head.
  
- 1 10. A head as recited in claim 1, wherein the head forms part of a CPP GMR sensor.
  
- 1 11. A magnetic head, comprising:  
2 an upper antiparallel (AP) pinned layer structure having at least two pinned layers  
3 having magnetic moments that are self-pinned antiparallel to each other;

4 a lower antiparallel pinned layer structure spaced apart from the upper AP pinned  
5 layer structure, the lower AP pinned layer structure having at least two  
6 pinned layers having magnetic moments that are self-pinned antiparallel to  
7 each other;  
8 a free layer structure positioned between the AP pinned layer structures, the free  
9 layer structure comprising:  
10 a first free layer having a magnetic moment;  
11 a second free layer having a magnetic moment pinned antiparallel to the  
12 magnetic moment of the first free layer; and  
13 a third free layer having a magnetic moment pinned antiparallel to the  
14 magnetic moment of the second free layer.

1 12. A head as recited in claim 11, wherein a net magnetic moment of the second and  
2 third free layers is negligible.

1 13. A head as recited in claim 11, wherein a thickness of each of the free layers  
2 perpendicular to planes of the free layers is less than about 100 Å.

1 14. A head as recited in claim 11, wherein a thickness of the first free layer is greater  
2 than thicknesses of the second and third free layers, individually, the thicknesses  
3 being measured in a direction perpendicular to a plane of the first free layer.

- 1 15. A head as recited in claim 11, further comprising hard bias layers positioned
- 2 towards opposite track edges of the free layer structure.
  
- 1 16. A head as recited in claim 11, wherein the second free layer is constructed of a
- 2 material having a lower electrical conductivity than the first and third free layers.
  
- 1 17. A head as recited in claim 16, wherein second free layer includes at least NiFe,
- 2 wherein the first and third free layers include at least CoFe.
  
- 1 18. A head as recited in claim 11, further comprising Cu spacer layers positioned
- 2 between the AP pinned layer structures and the free layer structure.
  
- 1 19. A head as recited in claim 11, wherein the head forms part of a GMR head.
  
- 1 20. A head as recited in claim 11, wherein the head forms part of a CPP GMR sensor.
  
- 1 21. A magnetic storage system, comprising:
- 2 magnetic media;
- 3 at least one head for reading from and writing to the magnetic media, each head
- 4 having:
- 5 a sensor having the structure recited in claim 1;
- 6 a write element coupled to the sensor;
- 7 a slider for supporting the head; and

8 a control unit coupled to the head for controlling operation of the head.

1 22. A magnetic storage system, comprising:

2 magnetic media;

3 at least one head for reading from and writing to the magnetic media, each head

4 having:

5 a sensor having the structure recited in claim 11;

6 a write element coupled to the sensor;

7 a slider for supporting the head; and

8 a control unit coupled to the head for controlling operation of the head.